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Dated 9 February 2004

270EC02 E773224-1 D02761
P01/7700 0.00-0229954.3

Patents Form 1/77

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Request for grant of a patent

(See the notes on the back of this form. You can also get and explanatory leaflet from the Patent Office to help you fill in this form)

1. Your reference — **P1079.GBA**

2. Patent application number *(The Patent Office will fill in this part)* — 0229954.3

3. Full name, address and postcode of the or of each applicant. *(underline all surnames)*

Newlands Technology Limited
Unit 3F Newlands Science Park
Inglemire Lane
HULL
HU6 7TQ

Patents ADP number *(if you know it)* — 07857451002

If the applicant is a corporate body, give the country/state of its incorporation — **United Kingdom**

4. Title of the invention — **ACTUATOR**

5. Name of your agent *(if you have one)* — **LOVEN & CO**

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Quantum House
30 Tentercroft Street
LINCOLN
LN5 7DB

Patents ADP number *(if you know it)* — **4467460003**

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
(a) any applicant named in part 3 is not an inventor, or
(b) there is an inventor who is not named as an applicant, or
(c) any named applicant is a corporate body
See note (d))

Yes

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	0
Description	5
Claim(s)	
Abstract	
Drawing(s)	3

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature Date **19 December 2002**

12. Name and daytime telephone number of person to contact in the United Kingdom **K J Loven (01522 801111)**

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

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ACTUATOR

Field of the Invention

This relates to a low profile variable force actuator.

Background to the Invention

Direct drive actuators employing active elements which are rods of magnetostrictive material are well known. The method of construction of these actuators means that although they deliver high force they have a physical profile that is unsuitable for many applications. Other active elements such as piezo can be incorporated into actuators that have a flat or narrow profile and may be suitable for many of the applications where a magnetostrictive actuator is unsuitable. However piezo actuators deliver comparatively low forces, require high voltages, about 100v, and are unsuitable for acoustic applications at frequencies below about 1 KHz. For these reasons piezo actuators may not be used. Higher force stacked piezo actuators are available but these are expensive, difficult to manufacture and tend to be unreliable. The height of the stack may also create an unacceptable profile. One potential solution to providing a high force, low profile actuator has been to use a flex-tensional envelope around an active element, as disclosed in US patent 4845688, that may be a magnetostrictive or piezo engine but this is still too bulky for many applications.

This invention describes a low profile, high force and/or variable force actuator design preferably using a magnetostrictive or stacked piezo engine but other active elements may be considered.

Summary of the Invention

According to this invention the engine or active element of the actuator may be any material that changes length under an external influence and exhibits high forces in so doing. For example this may be a stacked piezo or magnetostrictive engine or combination of the two.

In the normally constructed magnetostrictive direct drive actuator the height of the actuator is related to the length of the coil and the magnetostrictive element. In the low profile actuator using a magnetostrictive active element the overall height of the actuator is related to the cross section of the coil, rather than the length of the coil, and the

force is delivered in the direction of the shortest axis of the actuator, perpendicular to the length of the magnetostrictive element or coil. In a stacked piezo actuator the overall height of the actuator is related to the cross sectional dimension of the piezo stack and the force of actuation of the device is delivered perpendicularly to the direction of displacement. A low profile actuator of this type will be suitable for inclusion in many devices giving improved acoustic frequency bandwidth and volume compared with low profile piezo actuators that may be currently employed, or they may be included in devices to activate a surface when the device is resting on the surface. Examples include personal computers, personal digital assistants, CD and MP3 players and mobile phones.

Brief Description of the Drawings.

In the drawings, which illustrate exemplary embodiments of the invention:

Figures 1 to 3 are diagrammatic side views of various embodiments; and

Figures 4 and 5 illustrate an alternative embodiment.

Detailed Description of the Illustrated Embodiments

It has been found, by way of example, that a magnetostrictive actuator manufactured in this way, and measuring 6mm in the direction of actuating a panel, can produce the equivalent acoustic output of a direct drive magnetostrictive actuator measuring 30mm, when measured on a test panel, and employs a lower volume of magnetostrictive material. The low profile actuator is more efficient than the direct drive actuator in converting active element displacement into motion of the surface of a panel.

The active element, 11,21,31 drives horizontally and the construction of the actuator converts this motion into a vertically acting force using a hinge which is preferably a solid-state hinge 15, 25, 34 to reduce energy losses. A hinge with a pin and/or bearing surface would generate unacceptable losses because of the small amplitude of the movements involved. On one end or both ends of the active element is a curved bearing surface 12, 22, 32, 43 that may be part of the element or is more conveniently a separate piece of material of low compliance.

In the case of a magnetostrictive active element, for a given force and cross sectional area of the magnetostrictive rod, the height of the actuator may be further reduced by changing the dimensions of the cross section of the magnetostrictive rod so that it is no

longer square or circular but may be rectangular or elliptical and by using an elliptical coil. Further, the force may be increased without increasing the height of the actuator by employing a magnetostrictive rod of greater cross sectional area but maintaining one of the cross sectional dimensions and using an elliptical coil with rectangular or elliptical magnetostrictive material. It will be appreciated that separate coils, one on each side of the magnetostrictive element, may also result in a low profile actuator but the out put will be reduced compared with the output of a single coil wound around a single core of material.

In another embodiment of a low profile actuator the direction of actuation of the drive element may be at any angle to the surface being actuated for example 45 degrees as shown in fig 4, fig 4a. In this design the foot, 42, is of a low mass. The back mass, 40, is as far away from the pivot point, 45, as possible so that the effective mass of the back mass is increased as much as possible within the overall envelope of the design, and one of the dimensions of the actuator is no greater than the cross-section of the active element engine, 44, so that the profile of the actuator is suitable for applications where a narrow or low profile is required.

The solid state hinge, 15, 25, 34, 45 is constructed of low compliance material for example spring steel and to reduce energy losses the ratio between the thickness of the material comprising the hinge and the distance from the pivot point to the point where the hinge material is attached to the foot lever is between certain values.

As a result the actuator has a low profile and still delivers high force, comparable to a direct drive actuator, furthermore the device can be so arranged to deliver variable mechanical amplification and therefore variable force, Fig 3. This is achieved by moving the contact point, 35, 36 between the actuator foot and the surface being driven, towards, 36, and away from, 35, the pivot point. To optimise the output of the device the position of the back mass 30 also needs to be varied at the same time as the contact point is varied. The mechanical amplification may have a value less than, equal to or greater than 1.

Changing the mechanical amplification of this low profile actuator will change the frequency response of the device to which it is attached. Low mechanical amplification achieved by moving the contact point of the foot towards the pivot point emphasises the

higher frequencies and high mechanical amplification achieved by moving the contact point of the foot away from the pivot point emphasises the lower frequencies. In an audio device this means the frequency response can be altered according to the application. For example in public address applications frequencies below 800Hz are undesirable as they make speech harder to understand, but in other applications, such as listening to music, low frequencies are required.

In audio applications it has been found that increasing the back mass 10,20,30,40, increases the bass response. However if the back mass is arranged according to fig 1 the device is inefficient possibly because of flexure losses and the volume and frequency response is poor. Arranging the mass according to fig 2 and fig 3 improves the efficiency and the volume and bass responses.

In the drawings, the following reference numerals are used to identify the components listed:

10	Back Mass
11	Active Element
12	Domed Spacer
13	Leaf Spring
14	Foot
15	Pivot Point Solid State Hinge.
20	Back Mass
21	Active Element
22	Domed Spacer
23	Prestress spring
24	Foot
25	Pivot Point Solid State Hinge.
30.	Back Mass
31	Active Element
32	Domed Spacer
33	Prestress spring
34	Pivot Point Solid State Hinge.

35	Foot Positioned Forwards
36	Foot Positioned Closer to Pivot
40	Back Mass
41	Prestress Spring
42	Foot
43	Domed Spacer
44	Active element
45	Solid State Hinge

Fig 1.

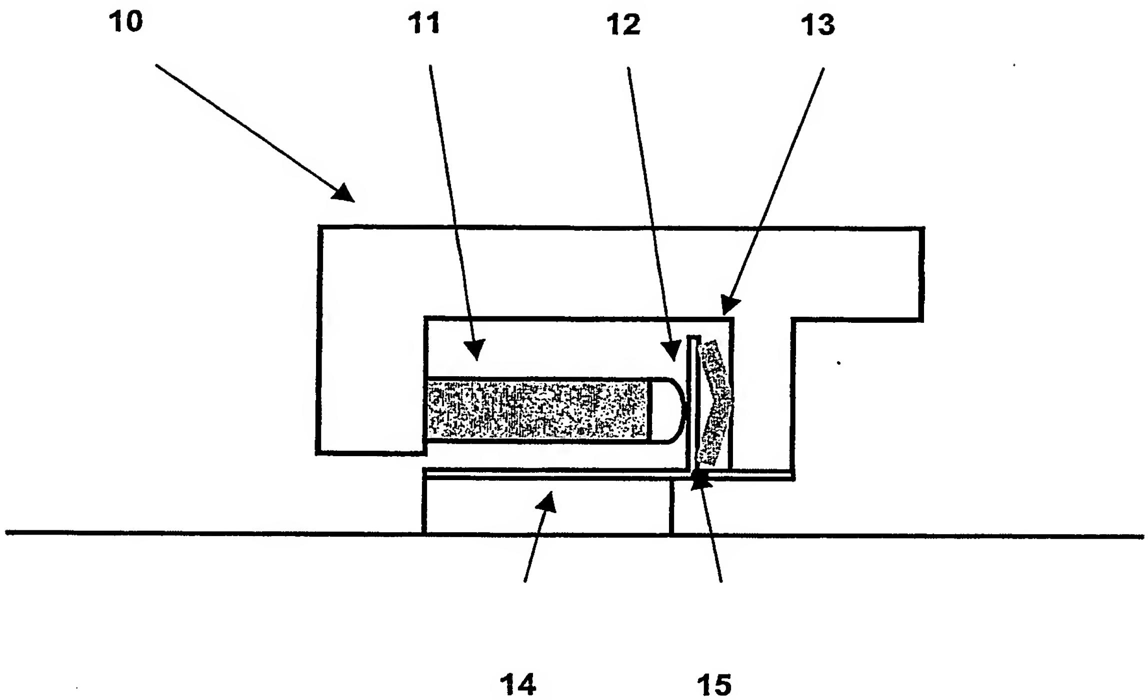

Fig 2.

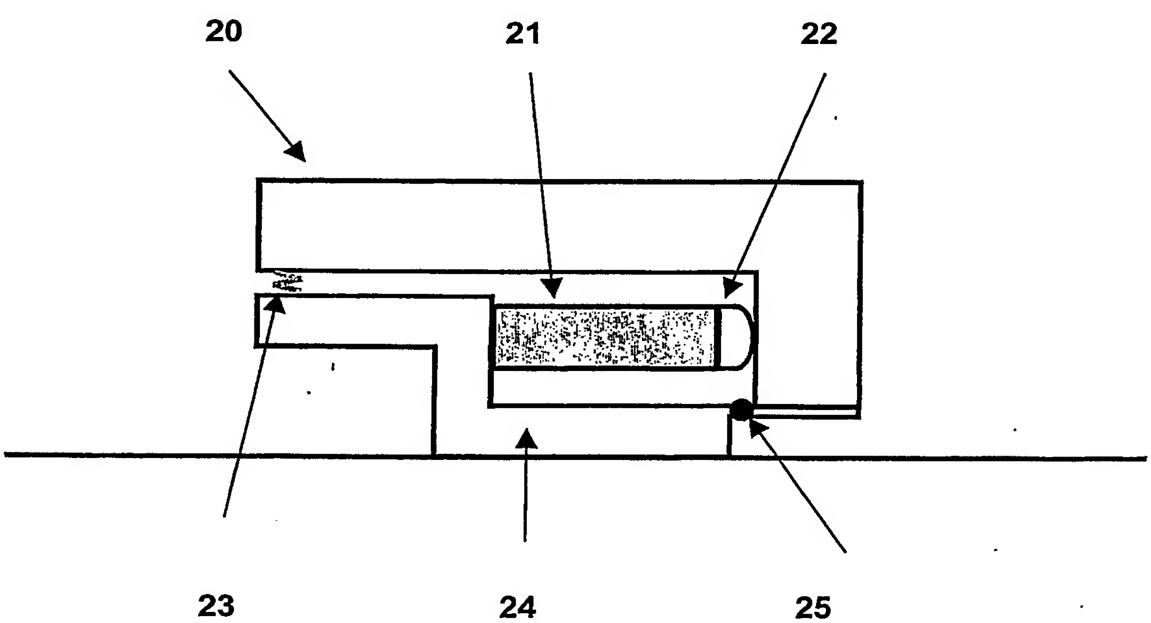

Fig 3.

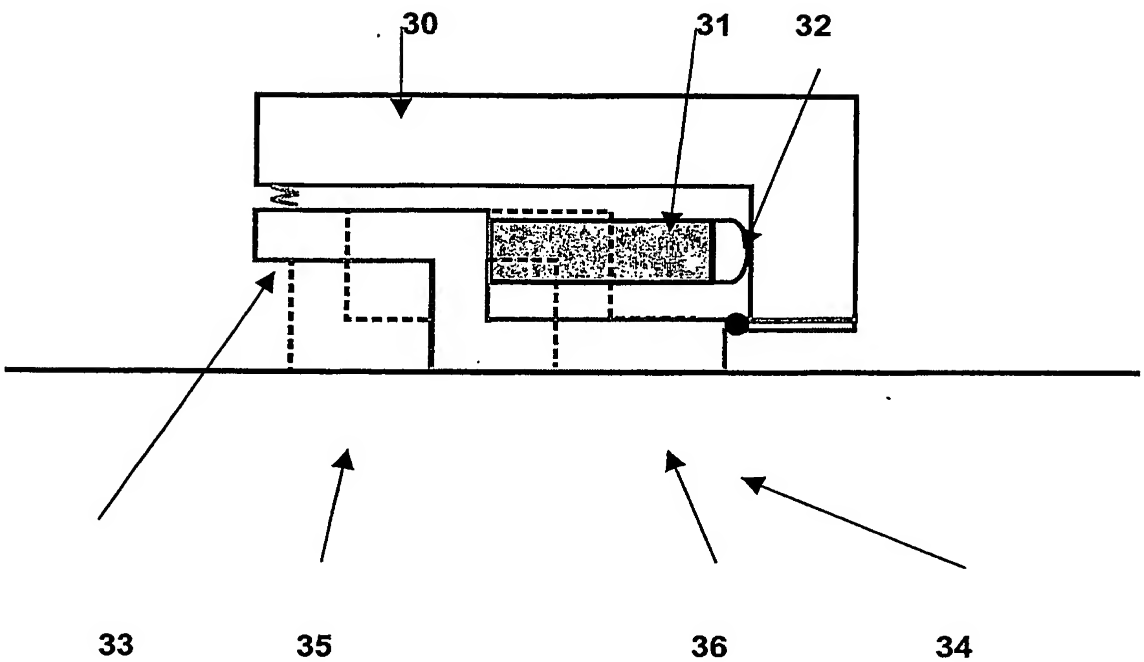

Fig 4.

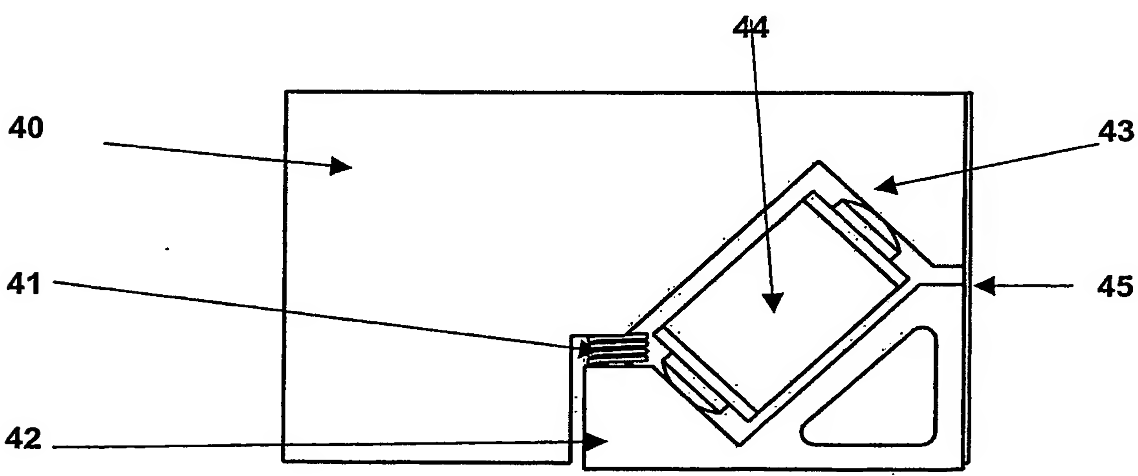

Fig 4a